

§8. Physical Mechanism of Collisionless Driven Magnetic Reconnection

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Dynamical evolution of collisionless driven reconnection and its dependence on physical parameters are examined by means of a particle simulation [1]. Figure 1 shows the temporal evolutions of reconnection electric field (a) for three different ion masses, and (b) for three different driving fields.

It is found that there exist two types of physical mechanism leading to magnetic reconnection in a collisionless plasma. One is responsible for a slow reconnection process associated with an ion meandering motion. This process becomes dominant when the width of the current layer becomes comparable to the orbit amplitude of the ion meandering motion ("ion current layer"). The other is responsible for a fast reconnection process associated with an electron meandering motion. This process becomes dominant after the electron current layer is compressed as thin as the orbit amplitude of the electron meandering motion ("electron current layer").

It is also found that the temporal evolution of the reconnection electric field scales as $E_0^{-1/2} M_i^{1/4}$ irrespective of whether the reconnection process is fast or slow, and the maximum reconnection rate is roughly in proportion to E_0 , where E_0 is the driving electric field at an input boundary and M_i is the ion mass. This scaling law can be explained by the following model. Both an ion and an electron are magnetized outside the ion current layer, while an ion is unmagnetized and an electron is magnetized inside the ion current layer. A convergent plasma flow carries the magnetic field from the boundary of the simulation box towards the ion current layer and compresses it. Since magnetized drift electrons can penetrate through the ion cur-

rent layer, magnetic flux can be carried inside. Thus, the ion current layer dynamically evolves while satisfying the balance between the plasma compression and the magnetic field penetration. The time scale of the magnetic field penetration is found to have the same proportionality as that of the reconnection electric field. This result leads us to the conclusion that the whole dynamic evolution of collisionless driven reconnection is controlled by the physics of the ion current layer.

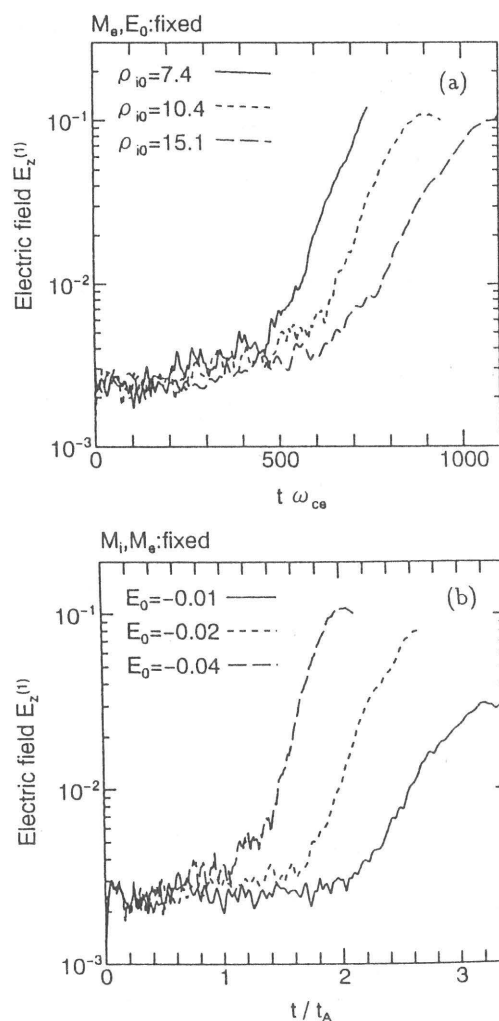


Fig. 1. Temporal evolutions of reconnection electric field (a) for three different ion masses, and (b) for three different driving fields.

References

- 1) R. Horiuchi and T. Sato, ICPP94 **3**, 169(1994); Phys. Plasmas **1**, 3587(1994).